15 CLIMATE CHANGE AND CARBON BALANCE

15.1 INTRODUCTION

This Chapter of the Environmental Impact Assessment Report (EIA Report) evaluates the effects of the Ackron Wind Farm (the Development) on the climate change and carbon balance resource, and presents a Climate Change Impact Assessment (CCIA). This assessment was undertaken by Heather Wylie, EIA Consultant, of Arcus Consultancy Services Limited (Arcus) and has been reviewed by Heather Kwiatkowski, Principal EIA Consultant at Arcus, and Stuart Davidson, Registered EIA Practitioner and Operational Director of Arcus.

This Chapter of the EIA Report is supported by Technical Appendix A15.1: Carbon Balance Calculations provided in Volume III.

This Chapter includes the following elements:

- Legislation, Policy and Guidance;
- Assessment Methodology and Significance Criteria;
- Baseline Conditions;
- Assessment of Potential Effects;
- Mitigation and Residual Effects;
- Cumulative Effect Assessment;
- Summary of Effects; and
- Statement of Significance.

15.2 LEGISLATION, POLICY AND GUIDANCE

The following legislation, policy and guidance have been considered in carrying out this assessment:

- Institute of Environmental Management and Assessment (IEMA) Environmental Impact Assessment Guide to Climate Change Resilience and Adaption 2020[1];
- Electricity Act 1989[2];
- Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017, as amended[3] (the EIA Regulations);
- The Electricity Generation Policy Statement (2013)[4];
- Letter from Chief Planner to all Heads of Planning in relation to energy targets and SPP (November 2015)[5];
- Scottish Energy Strategy (December 2017)[6];
- Onshore Wind Policy Statement (December 2017)[7];

[1] IEMA (2020) Environmental Impact Assessment Guide to Climate Change Resilience and Adaption 2020 [Online]. Available at: https://www.iema.net/resources/reading-room/2020/06/26/iema-eia-guide-to-climate-change-resilience-and-adaptation-2020 (Accessed 14/08/2020)
[2] UK Government (1989) Electricity Act 1989 [Online] Available at: https://www.legislation.gov.uk/ukpga/1989/29/contents (Accessed 14/08/2020)
[3] UK Government (2017) Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 [Online] Available at: https://www.legislation.gov.uk/ssi/2017/101/contents/made(Accessed 14/08/2020)
[4] Scottish Government (2013) Electricity Generation Policy Statement 2013 [Online] Available at: https://www.gov.scot/publications/electricity-generation-policy-statement-2013/ (Accessed 14/08/2020)
[5] Scottish Government (2015) Letter from Chief Planner to all Heads of Planning in relation to energy targets and SPP [Online] Available at: https://www.gov.scot/publications/energy-targets-and-scottish-planning-policy-chief-planner-letter/ (Accessed 14/08/2020)
[6] Scottish Government (2017) The Future of Energy in Scotland: Scottish Energy Strategy [Online] Available at: https://www.gov.scot/publications/scottish-energy-strategy-future-energy-scotland-9781788515276/ (Accessed 14/08/2020)
[7] Scottish Government (2017) Onshore Wind: Policy Statement [Online] Available at: https://www.gov.scot/publications/onshore-wind-policy-statement-9781788515283/ (Accessed 14/08/2020)

- European Commission Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment (2013)[8];
- HM Government UK Climate Change Risk Assessment Government Report (2012);[9]
- Scottish Government's Scottish Climate Change Adaption Programme[10]
- The Scottish Climate Change Plan (2018)[11];
- The Scottish Government's declaration of a Climate Emergency (April 2019)[12]; and
- The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019[13] and the legally binding net zero target for 2045 and interim targets for 2020, 2030 and 2040.

Notable information sources containing baseline and projected climate data include:

- Digest of United Kingdom Energy Statistics (DUKES) 2020[14];
- State of the UK Climate 2018[15];
- Met Office UK Climate Projections 2018 (UKCP18) (updated September 2019)[16]; and
- The Met Office UKCP18 Science Overview Report[17].

Other information sources are referenced throughout the Chapter.

15.3 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

15.3.1 Scoping Responses and Consultations

Consultation for this EIA Report topic was undertaken with various consultees; however, not all responded. Responses relevant to climate change are detailed in Table 15.1.

[8] European Commission (2013) Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment (2013) [Online] Available at: https://ec.europa.eu/environment/eia/pdf/EIA%20Guidance.pdf (Accessed 26/05/2020)
[9] HM Government (2012) UK Climate Change Risk Assessment: Government Report [online] Available at: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report (Accessed 21/08/2020)
[10] Scottish Government (2014) Scottish Climate Change Adaption Programme (SCCAP) [online] Available at: https://www.gov.scot/publications/climate-ready-scotland-scottish-climate-change-adaptation-programme/ (Accessed 21/08/2020)
[11] Scottish Government (2018) Climate Change Plan: Third Report on Proposals and Policies 2018 – 2031 (RPP3) [Online[Available at: https://www.gov.scot/publications/scottish-governments-climate-change-plan-third-report-proposals-policies-2018-9781788516488/ (Accessed 14/08/2020)
[12] Scottish Government (2019) Action to Address Climate Emergency [Online] Available at: https://www.gov.scot/news/action-to-address-climate-emergency/ (Accessed 13/08/2020)
[13] Scottish Government (2019) Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 [Online] Available at: http://www.legislation.gov.uk/asp/2019/15/enacted (Accessed 13/08/2020)
[14] UK Government (2020) Digest of United Kingdom Energy Statistics 2020 [Online] Available at: https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2020 (Accessed 12/08/2020)
[15] International Journal of Climatology, volume 39, Issue S1 (July 2019) ed. Radan Huth. Wiley
[16] Met Office (2019) UK Climate Projections – Updated September 2019[Online] Available at: https://www.metoffice.gov.uk/research/collaboration/ukcp (Accessed 13/08/2020)
[17] Lowe, J.A. *et al.* (2018) UKCP18 Science Overview Report. The Met Office. Available at: https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Overview-report.pdf (Accessed 13/08/2020)

Table 15.1 Consultation Responses

Consultee	Type and Date	Summary of Consultation Response	Response to Consultee
The Highland Council	Scoping Report Response, 6th June 2019. Updated Scoping Report Responses, 11th December 2019.	Address all relevant climatic factors which can greatly influence the impact range of many of the preceding factors on account of seasonal changes affecting, rainfall, sunlight, prevailing wind direction, etc.	Sections 15.4 and 15.5.1 present all information and assessment of the effects of the Development on climatic factors.
The Highland Council	Scoping Report Response, 6th June 2019. Updated Scoping Report Responses, 11th December 2020.	Consideration should be given to the disturbance and re-use of peat generally as highlighted by SEPA. Carbon balance calculations should be undertaken.	Section 15.5.2 presents results from the carbon calculator, including carbon loss and savings estimates, and payback time. Further detail is included in Technical Appendix A15.1.
SEPA	Scoping Report Response, 6th June 2019.	SEPA do not validate carbon balance assessments.	N/A

15.3.2 Scope of Assessment

The key issues for the assessment of potential climate change and carbon balance effects relating to the Development are:

- The vulnerability of the Development to climate change;
- The influence of the Development on climate change; and
- A summary of effects on environmental receptors sensitive to climate change.

The vulnerability of the Development to climate change considers effects on the Development as a receptor. In contrast, the other two assessments consider effects on environmental receptors as a result of the Development.

15.3.3 Elements Scoped Out of Assessment

The assessment of the influence of the Development on climate change focusses on the overall balance of greenhouse gas (GHG) emissions as climate change is directly linked to these emissions. No further analysis is undertaken of how climate parameters change in direct response to the emissions balance of the Development.

In relation to the effects on other environmental receptors, a qualitative review is undertaken in this Chapter of whether projected climate change will modify the future baseline without the Development sufficiently to change the results of the assessments undertaken in other chapters. The assessments are not repeated in this Chapter, which should be read in conjunction with the technical chapters.

15.3.4 Study Area / Survey Area

The study area considered for the assessment of vulnerability of the Development to climate change consists of the proposed infrastructure located within the site boundary (the Site), looking at changes over the planned lifetime of the 30 years from commissioning, *i.e.* until approximately 2055, assuming a year of construction in 2023. Information on climate trends and projections at the Scottish and local scale (where available) are utilised.

The study area for the assessment of the influence of the Development on climate change considers GHG emissions (current levels and targets) with renewable energy generation and grid mix within the Scottish and UK spatial scale. Reference is made to the global context as appropriate.

The study area for the assessment on future baseline for environmental receptors is outlined in individual technical chapters. Climate projections on a Scottish and Site scale (where available) are utilised for this Chapter.

15.3.5 Design Parameters

The design of the Development is a balance of technical, resource and environmental considerations. Those of relevance for the assessments in this Chapter include:

- Installed capacity and capacity factor - for calculation of GHG balance;
- Turbine spacing in relation to prevailing wind direction - for effects on generation, turbulence, vulnerability to damage with potential changes to wind speed, direction and storminess;
- Amount and layout of new track and infrastructure in relation to deep peat – for calculation of GHG balance;
- Buffers to watercourses – for assessing vulnerability to flooding due to changes in precipitation events; and
- Construction Management commitments particularly in relation to minimisation of disturbance and re-use of peat, and potential for flooding (as embedded in Appendix 4.1: Construction Environmental Management Plan (CEMP), Appendix 13.2 outline Peat Management Plan (oPMP), etc.) – for assessing potential emissions and vulnerability to flooding.

15.3.6 Baseline Survey Methodology

Climate trends and projections are published by the Met Office through the UK Climate Projections website. The UKCP18 became available in November 2018 and was most recently updated in September 2019. The UKCP18 provide the most up to date assessment of how the climate of the UK may change over this century.

UKCP18 uses scenarios for future greenhouse gas emissions called Representative Concentration Pathways (RCPs). The four RCPs attempt to capture a range of potential alternative futures and outcomes linked to global temperature increases and include a wide variety of assumptions on socioeconomic development and commitment to emissions reductions. The sensitivity of the scenario responses is much more pronounced in the second half of the 21^{st} century, where the responses diverge more rapidly than in the first half of the century. The four RCPs are as follows:

- RCP2.6: assumes an increase in global mean surface temperature of 1.6°C (-.9-2.3) by 2081-2100 (no change scenario);
- RCP4.5: assumes an increase in global mean surface temperature of 2.4°C (1.7-3.2) by 2081-2100 (low emissions scenario);
- RCP6.0: assumes an increase in global mean surface temperature of 2.8°C (2.0-3.7) by 2081-2100 (medium emissions scenario); and

- RCP8.5: assumes an increase in global mean surface temperature of 4.3°C (3.2-5.4) by 2081-2100 (high emissions scenario).

Over the 30-year anticipated lifetime of the Development, the choice of scenario is therefore not fundamental to the assessment but, where appropriate, the medium emissions scenario RCP6.0 is utilised as the future baseline. Reflecting the Paris Climate Agreement[18], in which most countries including the UK pledged to reduce emissions by 2030, this scenario assumes no further emissions reductions after 2030 and allows for some increase in emissions.

Projections are reported for 20-year time periods through to 2100. The 2021 – 2040 and 2041 - 2060 periods provide the closest projections to the operational phase of the Development. For the purpose of this CCIA, where appropriate the 2040-2059 time period is used as the impacts of climate change are anticipated to be more evident with time.

Projected climatic changes at the 50% probability level (central estimate) are utilised, unless otherwise indicated. This is the level where there is as much evidence pointing to a lower outcome as a higher one. There is substantial evidence that the actual climatic change outcome will be in the 10th to 90th percentile range and this is also utilised for limited assessment parameters[19].

15.3.6.1 Vulnerability of the Development to Climate Change

This section of the CCIA identifies aspects of the Development which are potentially vulnerable to the effects of climate change. Where identified, these vulnerabilities can then be mitigated through embedded mitigation or the application of other measures.

Taking into account the nature and location of the Development, the following climate related parameters are considered to have the potential to impact upon the operation of the Development:

- Wind (speed, direction and gustiness);
- Temperature; and
- Precipitation.

The construction and decommissioning stages of the Development are not considered to be vulnerable to climate change and have been scoped out of further consideration.

15.3.6.2 Influence of the Development on Climate Change

This section of the CCIA seeks to quantify the effect of the Development on climate change.

Scottish Planning Policy (SPP)[20] states that energy infrastructure developments are required to identify their effects on carbon rich soils, using the Scottish Government's Carbon Calculator. This has been completed for the Development using the latest version of the calculator (C-CalcWebV1.6.1)[21]. The carbon assessment methodology used is consistent with that published by the Rural and Environment Research and Analysis Directorate of the Scottish Government entitled 'Calculating carbon savings from wind

[18] United Nations (2016) Framework Convention on Climate Change. Adoption of the Paris Agreement, 21st Conference of the Parties, Paris [Online] Available at: https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf (Accessed 13/08/2020)
[19] Lowe et al (2018) UKCP18 Science Overview Report (Page 13)
[20] Scottish Government (2014) Scottish Planning Policy [Online] Available at: https://www.gov.scot/publications/scottish-planning-policy/ (Accessed 13/08/20)
[21] Scottish Government & SEPA. Carbon Calculator Tool v1.6.1.1 [Online] Available at: https://informatics.sepa.org.uk/CarbonCalculator/index.jsp (Accessed 13/08/20)

farms on Scottish peat lands – a new approach'[22]. This publication sets out the approach and assumptions that should be used to estimate potential carbon losses and savings from wind farms on Scottish peatlands. The carbon calculator is included as Technical Appendix A15.1, Volume III.

The calculation evaluates the balance of total carbon savings and carbon losses over the life of the Development. The potential carbon savings and carbon costs associated with wind farms are as follows:

- Carbon emission savings due to generation (based on displacing emissions from different power sources);
- Lifetime costs associated with manufacture of turbines and construction;
- Loss of carbon from backup power generation;
- Loss of carbon-fixing potential of peatland;
- Loss and/or saving of carbon stored in peatland (by peat removal or changes in drainage);
- Loss and/or saving of carbon-fixing potential as a result of forestry clearance; and
- Carbon gains due to proposed habitat improvements such as bog restoration.

The calculation of the carbon balance of a proposed wind farm provides a mechanism by which the carbon costs of a wind farm development can be weighed against the carbon savings attributable to the wind farm during its lifetime. This calculation is summarised as the length of time (in years) it will take the carbon savings to amount to the carbon costs and is referred to as the 'payback period'. This information can then inform decision makers of the viability of a wind farm development in terms of overall carbon savings.

Calculations are provided for expected, best and worst-case scenarios of Development. Whilst the Development has a proposed total installed capacity up to 49.9 MW, it is considered best practice to calculate the carbon balance and carbon emissions of the Development using a specific candidate turbine in order to produce more accurate and realistic results. For the purposes of assessment, the expected scenario is based on the layout of 12 turbines and a 4 Mega Watt (MW) turbine with a total installed capacity of 48 MW. The other scenarios are based on varying assumptions regarding wind energy capacity factor, characteristics of peatland and Development land-take.

The data sources and assumptions used in the carbon balance calculation are detailed in Technical Appendix A15.1. The assessment was informed by peat probing, as described in **Chapter 13: Geology and Peat**.

15.3.6.3 Effects on Environmental Receptors Sensitive to Climate Change

This section of the CCIA identifies where climate change has the potential to significantly impact the findings of assessments undertaken and reported elsewhere in this EIA Report. Reference is made to the specific assessment chapters, where the baseline conditions and sensitivity of receptors are discussed, assessments are not repeated.

15.3.7 Methodology for the Assessment of Effects

The significance of the potential effects of the Development has been classified by professional consideration of the sensitivity (value and resilience) of the receptor and the magnitude of the potential effect, taking into account uncertainty, to determine whether effects are significant under EIA Regulations. This is based on the professional judgement of the assessor.

[22] Nayak et al (2008) Calculating carbon savings from wind farms on Scottish peat lands: a new approach (Scottish Government) [Online] Available at: https://www.gov.scot/publications/2008/06/25114657/0 (Accessed 13/08/20)

15.3.7.1 Sensitivity of Receptors

The sensitivity of the baseline conditions, including the importance of environmental features on or near to the Site or the sensitivity of potentially affected receptors, will be assessed in line with best practice guidance, legislation, statutory designations and / or professional judgement.

Table 15.2 details the framework for determining the sensitivity of receptors.

Table 15.2 Framework for Determining Sensitivity of Receptors

Sensitivity of Receptor	Definition
Very High	The receptor has little or no ability to absorb change without fundamentally altering its present character, is of very high environmental value, or of international importance.
High	The receptor has low ability to absorb change without fundamentally altering its present character, is of high environmental value, or of national importance.
Medium	The receptor has moderate capacity to absorb change without significantly altering its present character, has some environmental value, or is of regional (e.g. Highland-wide) importance.
Low	The receptor is tolerant of change without detriment or benefit to its character, is low environmental value, or is of local importance.
Negligible	The receptor is resistant to change and is of little environmental value.

15.3.7.2 Magnitude of Change

The magnitude of change will be identified through consideration of the Development, the degree of change to baseline conditions predicted as a result of the Development, the duration and reversibility of an effect and professional judgement, best practice guidance and legislation.

The criteria for assessing the magnitude of change are presented in Table 15.3.

Table 15.3 Framework for Determining Magnitude of Change

Magnitude of Change	Definition
High	A fundamental change (positive or negative) to the baseline condition of the receptor, leading to total loss or major alteration of character.
Medium	A material change (positive or negative) leading to partial loss or alteration of character.
Low	A slight, detectable, alteration of the baseline condition which may be positive or negative.
Negligible	A barely distinguishable change from baseline conditions.

15.3.7.3 Significance of Effect

The sensitivity of the asset and the magnitude of the predicted change will be used as a guide, in addition to professional judgement, to predict the significance of the likely effects.

The IEMA guidelines for the CCIA state the following with regards to the assessment of significance:

"This guidance is not proposing changes to the significance criteria used in the EIA process. However, the susceptibility or resilience of the receptor to climate change must be considered as well as the value of the receptor.

Therefore, a high-value receptor that has very little resilience to changes in climatic conditions should be considered more likely to be significantly affected than a high-value receptor that is very resilient to changes in climatic conditions.

The uncertainty of the combined effect needs to be taken into account. If uncertainty about how a receptor will adapt to a changing climate is high, then it is recommended that a conservative threshold of significance is adopted within the evaluation".

Table 15.4 outlines the framework for determining significant effects, which is supported heavily by professional judgement.

Table 15.4 Framework for Assessment of the Significance of Effects

Magnitude of Change	**Sensitivity of Resource or Receptor**				
	Very High	**High**	**Medium**	**Low**	**Negligible**
High	Major	Major	Moderate	Moderate	Minor
Medium	Major	Moderate	Moderate	Minor	Negligible
Low	Moderate	Moderate	Minor	Negligible	Negligible
Negligible	Minor	Minor	Negligible	Negligible	Negligible

Those predicted to be of major or moderate significance are considered to be 'significant' in the context of the EIA Regulations, and are shaded in light grey in the above table.

The categories of effect are described in Table 15.5.

Table 15.5: Categories of Effect

Significance	**Definition**
Major	A fundamental change to location, environment, species or sensitive receptor.
Moderate	A material, but non-fundamental change to a location, environmental, species or sensitive receptor.
Minor	A detectable but non-material change to a location, environment, species or sensitive receptor
Negligible	No detectable or material change to a location, environment, species or sensitive receptor.

Effects assessed can be both negative and neutral. Whilst receptors may be considered "high-value", a non-material magnitude of the impact would result in any effect being considered not significant.

15.3.8 Assessment Limitations

The climate change projections are based on global models for a range of GHG emissions scenarios and generally consider regional responses to climate change rather than local responses. This is based on best scientific knowledge at this time and judgements on datasets and future socioeconomic drivers.

Downscaling adds another level of uncertainty. There may be more detail, but the uncertainty of the science may be higher. As understanding of the climate system and ability to model it improves it is likely that future projections will be refined.

The probabilities presented and the estimated ranges are based on a set of modelling, statistical and dataset choices with expert judgement playing an important role. As some potential influences on future climate are not yet known, some choices may change as the science develops[23].

In relation to wind, the UKCP18 Wind Fact sheet[24] states that local variations due to the land surface are hard to model, particularly in very exposed or sheltered locations. This can be particularly relevant in high wind speed situations where local gusts can result from small scale weather events such as thunderstorms.

15.3.9 Embedded Mitigation

As detailed in **Chapter 4 – Development Description**, the design of the Development has been driven by the key objective of capturing the maximum energy possible, while balancing environmental and technical constraints. The design choices made as a consequence of the key constraints are considered to be mitigation which is 'embedded' in the design; the following are most relevant for the CCIA:

- Development infrastructure is built to withstand strong windspeeds and to harness energy;
- Turbine spacing is sufficient to reduce turbulence effects on turbines downwind;
- The turbines are located to maximise energy generation while minimising environmental impacts;
- The Development design aims to reduce impacts on peat – e.g. through use of existing track layout where possible and avoiding areas of deep peat;
- Implementation of a CEMP, PMP etc. during construction to minimise environmental impacts and peat disturbance; and
- Buffers from watercourses incorporated in layout design, protecting water quality and also protecting Development infrastructure from flooding.

15.4 BASELINE CONDITIONS

The State of the UK Climate 2018[25] provides the latest report on observed climate data for UK. Key findings are as follows:

- The most recent decade 2010-2019 has been on average 0.3°C warmer than the 1981-2010 average and 0.9°C warmer than 1961-1990;
- February 2019 was the second warmest February since 1884 and the warmest February for daily maximum temperature;
- The years 2014 through 2019 all rank among Europe's six warmest years on record;
- The most recent decade (2010–2019) has been on average 1% wetter than 1981–2010 and 5% wetter than 1961–1990 for the UK overall. Six of the ten wettest years for the UK in a series from 1862 have occurred since 1998;
- 2019 UK rainfall was 107% of the 1981-2010 average and 112% of the 1961-1990 average;
- For the most recent decade (2010–2019), UK summers have been on average 11% wetter than 1981–2010 and 12% wetter than 1961–1990;
- 2019 was the sixth consecutive year where the number of air and ground frosts was below average; and
- The most recent decade (2010–2019) has had 6% fewer days of air frost and 10% fewer days of ground frost compared to the 1981–2010 average, and both 16% fewer compared to 1961–1990.

[23] Lowe *et al* (2018) UKCP18 Science Overview Report
[24] UKCP18 (2019) Factsheet: Wind [Online]. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-wind.pdf (Accessed on 14/08/2020)
[25] International Journal of Climatology, volume 39, Issue S1 (July 2019) ed. Radan Huth. Wiley

Climate Projections show that the trends over the 21st century in the UK are towards warmer and wetter winters and hotter, drier summers, with an increase in frequency and intensity of extremes.

The climate parameters considered most relevant to the assessments referenced within this Chapter are wind speed, temperature and precipitation.

15.4.1 Wind Speed

The global projections over the UK show an increase in near surface (10 metre [m] height) wind speeds over the UK in the second half of the 21st century, in the winter season when higher wind speeds are generally experienced. The increase is modest when compared to inter-annual variability. This would be accompanied by an increase in frequency of winter storms over the UK[26]. There are no significant changes forecast in the wind speeds over the first part of the century.

These projections are in line with earlier findings by Pryor and Barthelmie (2010)[27] who concluded that in the near-term (i.e. until the 2050s) there will be no detectable significant change in the wind resource of northern Europe.

15.4.2 Temperature

At a UK level, for period 2041 - 2060 projected changes to annual mean temperature (compared to 1981-2000) is projected at +1.8°C (50% probability) for RCP8.5 (unmitigated scenario). Results for the 10th to 90th percentile range are between +0.9°C to +2.7°C[28]. Key observations are that:

- Both winters and summers will be warmer, with more warming in the summer; and
- In summer, there is a pronounced north/south divide with greater increases in maximum summer temperatures over the southern UK compared to Northern Scotland.

15.4.3 Precipitation

Rainfall patterns over the UK are not uniform and vary on regional (e.g. Highland-wide) and seasonal scales, which will continue in the future. Future changes are uncertain but point to wetter winters and drier summers in general. Drying in summer will be strongest in the South of England, whilst Northern Scotland, where the Site is situated, is associated with greatest increased precipitation in winters[29].

Over the UK, the changes to precipitation projected for 2041-2060 (compared to 1981-2000) for RCP8.5 (unmitigated scenario) are:

- Winter precipitation – increase of 7%. Results for the 10th to 90th percentile range are between -5% and +21%; and
- Summer precipitation – decrease of 15%. Results for the 10th to 90th percentile range are between -31% and +0%.

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[26] UKCP18 (2018) Factsheet: Wind.
[27] Pryor, S.C. and Barthelmie, R. J. (2010) Climate Change Impact on Wind Energy: A Review. Renewable and Sustainable Energy Review, 14(1): 430-437
[28] Lowe *et al* (2018) UKCP18 Science Overview Report November 2018 (Updated March 2019) (Table 2.2, Page 16)
[29] Lowe *et al* (2018) UKCP18 Science Overview Report

15.4.4 Greenhouse Gas Emissions and Renewable Energy

The central aim of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C[30].

A substantial reduction in greenhouse gas emissions is imperative to avoid irreversible damage caused by the impacts of climate change. *"When it comes to rises in global average temperature, every fraction of a degree matters"* was stated in a recent publication providing analysis for the Global Carbon Budget 2018[31].

The 2018 IPCC Special Report[32] highlighted that to limit global warming to below 1.5°C by the end of the century, emissions would need to decline by approximately 45% by 2030 and reach net zero around 2050. This is the temperature rise when a variety of increasingly severe effects are considered to occur and the IPCC identifies that rapid and far-reaching transitions are required in all sectors including energy. Action is required immediately to reduce emissions by 50% by 2030. However, figures from the Global Carbon Project report that global CO^2 emissions from fossil fuels and industry have increased every decade from an average of 11.4 gigatonnes of equivalent carbon dioxide ($GtCO_2$) in the 1960s to an average of 34.7$GtCO_2$ during 2009-2018. Emissions in 2018 reached a new record high of 36.6$GtCO_2$. Though global emissions in 2019 have been project to increase by an additional 6%, which is a slower growth than in the past two years.

The Scottish Government has introduced a number of policies aimed at reducing GHG emissions and meeting renewable energy targets set at a UK, European and International level with ambitious targets for reductions in greenhouse gas emissions. The Climate Change Bill, which amends the Climate Change (Scotland) Act 2009, was introduced to Parliament in May 2018.The Bill was passed in September 2019 and received Royal Assent in October 2019. Following the Committee on Climate Change recommendation, the Bill was amended to set a new target to cut Scottish greenhouse gas emissions to net zero by 2045, five years ahead of the target date set for the whole of the UK, with interim targets now set to cut emissions by 75% and 90% by 2030 and 2040 respectively (in relation to 1990 levels).

The 2nd Scottish Climate Change Adaptation Programme 2019 - 2024 was published in September 2019. This document sets out the Scottish Government's policies and proposals for climate change adaptation, building on the 1st five-year programme. The Programme is a requirement of the Climate Change (Scotland) Act 2009.

Overall Scottish emissions are now 49% below 1990 levels though the Scottish Parliament's 2030 target to reduce emissions by 75% will be extremely challenging to meet. To date much of the emissions savings have come from action in the electricity sector, with closure of Scotland's last remaining coal-fired power station in 2016, and rapid growth in renewable generation to fill the energy gap.

Renewable generation capacity in Scotland has more than trebled in the last 10 years with 11.6 gigawatts (GW) of installed generation capacity across the country as of 2019[33].

[30] UN Climate Change (2015) the Paris Agreement [Online] Available at: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (Accessed 4/08/2020)
[31] Additional Analyses for Carbon Budget 2018**:** Emissions are still rising: ramp up the cuts by Figueres, C., C. Le Quéré, G. P. Peters, G. Whiteman, A. Mahindra, D. Guan, et al. (2018), Nature, vol 564, 27-30, 2018 [Online] Available at: http://www.globalcarbonproject.org/carbonbudget/18/publications.htm (Accessed 4/08/2020)
[32] Intergovernmental Panel on Climate Change (IPCC) (2018) Global Warming of 1.5°C: Summary for Policymakers [Online] Available at: https://www.ipcc.ch/sr15/ (Accessed 4/08/2020)
[33] Scottish Government (2019) Climate Change Plan: monitoring report 2019 [online] Available at: https://www.gov.scot/publications/climate-change-plan-monitoring-report-

Consequently, renewables contribution towards the total volume of electricity generated has grown from 18.5% in 2008 to 51.7% in 2017. GHG emissions from the electricity sector decreased by 83% between 1990 and 2016, with the Cities for Climate Protection (CCP) setting out policies and proposals to reduce emissions from this sector by a further 28% between 2018 and 2032, taking the overall reduction within the sector to 87% compared to 1990.

With the continued development of onshore wind farms, in the planning and pre-construction phases, it is anticipated that onshore wind farms will continue to make a sizeable contribution to the energy generated from renewable energy technologies within Scotland. The CCP sets out as one of the policy outcomes for this sector that from 2020 onwards, Scotland's electricity generation intensity will be less than 50 grams of carbon dioxide equivalent per kilowatt hour (CO_2eq/kWh), powered by a high penetration of renewables. The CCP latest figures for 2017 show intensity was 24gCO_2e/kWh which displays a fall of 56% since 2016[34].

15.5 ASSESSMENT OF POTENTIAL EFFECTS

As an energy asset of generation of up to 49.9 MW, the Development can be classed as an asset of regional importance therefore considered to be of medium sensitivity for the following assessments.

15.5.1 Vulnerability of the Development to Climate Change

15.5.1.1 Wind Speed

As energy content of the wind varies with the cube of the average wind speed[35], small increases in wind speed can result in large increases in wind power. There is a higher risk of damage from strong winds; winds associated with major storm events can be some of the most damaging and disruptive events for the UK with implications for infrastructure.

Wind turbines are designed to capture wind energy, and built to withstand extreme conditions associated with exposed locations. However, wind energy developments could potentially be sensitive to significant changes in variables, including atmospheric circulation and land cover changes as well as changes in the frequency of extreme events (e.g. storms), which could damage wind turbines or alter their efficiency.

Over the lifetime of the Development, UKCP18 states that there are no compelling trends in storminess (as a result of maximum gust speeds) over the last four decades and for wind speed change there is little long-term trend evident. Therefore, the natural variability which exists in wind speed, and subsequently storms, will have a negligible magnitude of change on energy projections and on the efficient operation of the Development.

Given the negligible magnitude of the change and the medium sensitivity of the Development as a receptor, the effect is assessed as negligible and **not significant** in terms of the EIA Regulations predicted as a result of increased wind speeds during the operational phase of the Development.

2019/pages/3/#:~:text=Renewable%20electricity%20generation%20capacity%20in,2008%20to%2051.7%25%20in%202017.

[34] Scottish Government (2019) Climate Change Plan: monitoring report 2019 [online] Available at: https://www.gov.scot/publications/climate-change-plan-monitoring-report-2019/pages/3/#:~:text=Renewable%20electricity%20generation%20capacity%20in,2008%20to%2051.7%25%20in%202017.

[35] Energy Savings Trust (2019) Wind Turbine: Measuring Wind Speed [Online] Available at: https://www.energysavingtrust.org.uk/sites/default/files/reports/wind%20turbine_measuring%20wind%20speed.pdf (Accessed on 14/08/20)

15.5.1.2 Temperature

Wind energy developments are sensitive to cold weather events and ice forming on blades, although in the UK this has rarely been an issue and where icing does occur the turbines' own vibration sensors are likely to detect the imbalance and inhibit the operation of the machines36. With the projected trend to warmer conditions, the predicted magnitude of change is negligible. The effect is assessed as negligible and therefore **not significant** in terms of the EIA Regulations.

15.5.1.3 Precipitation

The risk from increased precipitation is the potential for flooding, particularly if it is associated with extreme events. For the Development, this increases the risk for potential destruction/disruption of infrastructure, *e.g.* loss of watercourse crossing, flooding to control building. The Development has only one watercourse crossing and buffers from watercourses are embedded in the design of the Development, as are best practice drainage design and a CEMP (oCEMP) detailed TA4.1). As such, the Development has medium sensitivity to increase in precipitation.

UKCP18 shows that over the winter season, precipitation in this area of Scotland is projected to increase by up to 30% at the medium estimate. Given the embedded mitigation, the magnitude of change on the operation of the Development is assessed as low and the overall effect is minor and therefore, not significant.

15.5.2 Influences of the Development on Climate Change

15.5.2.1 Carbon Savings

Every unit of electricity produced by a wind farm development displaces a unit of electricity which would otherwise have been produced by a conventional (coal or gas) power station, and therefore presents carbon savings.

The electricity produced from the wind farm is assumed to substitute energy production by entirely coal-fired generation, or a mix of fossil fuels, or the national grid mix of energy generation. A renewable energy development would have a maximum potential to save carbon emissions when substituting coal fired generation, which is a possibility if coal is at the bottom of the cost merit order of generation.

However, it is not appropriate to define the electricity source for which this renewable electricity project would substitute, due to uncertainty in future grid mix. For this reason, carbon emission savings are calculated for each scenario in the carbon calculator (Technical Appendix A15.1).

As detailed in Section 15.3.6.2, whilst the Development has a proposed installed capacity of up to 49.9 MW, for the purpose of this assessment, a 4 MW candidate turbine has been selected. With an installed capacity of 48 MW (12 4 MW turbines) and an anticipated capacity factor of 42.6%, the amount of electricity produced by the Development in the expected scenario has been estimated to be approximately 179,124 Mega Watt hours (MWh) annually, equating to powering the equivalent of approximately 45,826 Scottish homes annually, based on the latest available figures from 2018[37].

[36] IEA Wind (2018) IEA Wind TCP Task 19 INTERNATIONAL RECOMMENDATIONS for Ice Fall and Ice Throw Risk Assessments [Online] Available at: https://community.ieawind.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=3e92fc30-a54a-4888-e612-79126301c58e&forceDialog=0 (Accessed 14/08/2020)

[37] Department for Business, Energy & Industrial Strategy (2018) Electricity generation and supply figures for Scotland, Wales, Northern Ireland and England, 2004 to 2017 [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766072/Regional_Electricity_Generation_and_Supply.xls (Accessed 26/11/2020)

This equates to displacing approximately 2,418,180 tonnes of fossil fuel mix generation equivalent CO_2 emissions, based on DUKES emission factors[38], over the operational life which is a beneficial environmental effect. The projected change in wind speeds as a result of climate change over the operational phase of the Development is considered to be non-material for the purposes of this assessment.

Table 15.6: Carbon Savings for the Development (Expected scenario)

Type of Generation	Expected CO_2 Saving (t C02yr-1)
Coal fired electricity generation	164,795
Grid mix electricity generation	45,422
Fossil fuel mix electricity generation	80,606

15.5.2.2 Carbon Losses

The manufacturing, construction and installation of the wind turbines on the Site will have an associated carbon cost, and carbon losses are also generated by the requirement for extra capacity to back up wind power generation. Carbon losses associated with reduced carbon fixing potential and loss of soil organic matter occurs through excavation of peat for construction and drainage effects.

Organic soils (peatlands) in Scotland act as carbon sinks, whereby they absorb CO_2 then they release it due to land use change, such as forestry. Wind farm developments on peatlands may result in an adverse impact on these habitats if not appropriately considered during scheme design and development. Changes to the peatland habitat through development could result in a significant effect on its ability to store carbon, potentially resulting in reduced net carbon benefits of the Development.

A peat depth surveys were undertaken over a series of site visits where it was established that peat was generally shallow across the Site, varying only with depth according to local topographical conditions, with pockets of deep peat situated in topographically flat areas or in the vicinity of bodies of water. There are no designations within the Site; however, two Natura 2000 Sites are located adjacent to the east of the Site; the Caithness and Sutherland Peatlands Special Protection Area (SPA)[39] and Special Area of Conservation (SAC)[40]. The Site is also adjacent to the Caithness and Sutherland Peatlands Ramsar Site, and the East Halladale Site of Special Scientific Interest (SSSI)[41].

The design process sought where possible to avoid disturbance to deposits of deep peat. A Habitat Management Plan (HMP) will be implemented in accordance with the Ackron Wind Farm HMP and aims to provide a summary of the broad ecological aims and objectives of the HMP and can be seen in **Chapter 7: Ecology,** Section 7.6.5. Objective 1 of the HMP seeks to restore degraded peatlands to positively contribute to maintaining the integrity of nearby European designated sites (Caithness and Sutherland Peatland), as well as improving biodiversity value of degraded habitats within the Site. This includes a Peatland Restoration Area which is yet to be fully defined in the HMP however, it is likely to include all restorable peatland habitats out with close proximity to the Development in the south and south east of the Site, which currently comprises drained

[38] DUKES (2018) Digest of United Kingdom Energy Statistics 2020[Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/905060/DUKES_2020_MASTER.pdff (Accessed 14/08/20)
[39] SNH (n.d.) Caithness and Sutherland Peatlands SPA [Online] Available at: https://sitelink.nature.scot/site/8476 (Accessed 14/08/20)
[40] SNH (n.d.) Caithness and Sutherland Peatlands SAC [Online] Available at: https://sitelink.nature.scot/site/8218 (Accessed 14/08/20)
[41] SNH (n.d.) East Halladale SSSI [Online] Available at: https://sitelink.nature.scot/site/585 (Accessed 14/08/20)

peatland habitats. This work will reduce the carbon losses associated with the Development.

Carbon losses for the expected scenario are summarised in Table 15.7.

Table 15.7: Carbon Losses for the Development (Expected Scenario)

Losses	t CO_2 Equivalent (total for wind farm lifetime)
Losses due to turbine life (e.g. manufacture, construction, decommissioning)	42,161
Losses due to back-up	14,191
Losses due to reduced carbon fixing potential	826
Losses from soil organic matter	22,945
Losses due to Dissolved Organic Carbon (DOC) and Particulate Organic Carbon (POC) leaching	3,285
Losses due to felling forestry	5436
TOTAL LOSSES	**86,058**

15.5.2.3 Payback Period

The carbon payback period is a measurement/indicator to help assess a proposed development. The shorter the payback, the greater benefit the Development will have in displacing emissions associated with electricity generated by burning fossil fuels.

The payback period is calculated taking the total carbon cost (carbon losses) associated with the Development and dividing by the annual carbon gains from displaced fossil fuel power generation and any site improvements (e.g. peatland restoration).

The estimated payback period for the Development is 1.8 years compared to grid-mix electricity generation. In comparison to fossil fuel mix and coal-fired electricity generation, the payback period of the Development reduces to 1 year and 0.5 years respectively. Table 15.8 below goes into further detail regarding the carbon payback period for the Development.

Table 15.8: Payback in Years for Each Scenario in the Carbon Calculator

Compared to…	Expected Scenario	Best Case Scenario	Worst Case Scenario
Coal fired electricity generation	0.5	0.4	0.7
Grid-mix electricity generation	1.8	1.3	2.5
Fossil fuel-mix of electricity generation	1.0	0.8	1.4

The CO_2 emission savings for the operational lifetime beyond that (currently predicted as 30 years) would a net benefit of the Development to reducing climate change. This is considered a low magnitude of change, *i.e.* a slight, detectable, alteration of the baseline condition.

Given the challenge and international urgency of climate change, as identified in the recent IPCC special report, the climate is considered to have very high sensitivity to changes in GHG emissions. The Development is therefore assessed to have moderate, positive effects that is a **positive significant effect** under the EIA Regulations.

15.5.3 Effects of Future Climate Change Scenario on Environmental Receptors Sensitive to Climate Change

The potential for environmental receptors to be impacted by the Development is assessed in Chapters 6 - 16 of this EIA Report. Of these, it is considered that ecological, ornithological, peat, geological and hydrological receptors are the most sensitive to climate change and are discussed further in Table 15.9 below.

Table 15.9: Climate Change Effects on Environmental Receptors

EIA Report Chapter	Receptor	Climate Change Effect	Effect on Receptor
7	Ecology	Temperature – up to + 2.7°C Shift to wetter winters and dryer summers Negligible change in wind speeds	While changes in temperature could affect the composition and growth rates of plant communities and invertebrates, and hence protected species and habitats, the uncertainties are high and it is not clear that the effect of the Development on those receptors would alter substantially as a result.
8	Ornithology	Temperature – up to + 2.7°C Shift to wetter winters and dryer summers Negligible change in wind speeds	A rise in temperature has the potential to impact on habitats which in turn may affect the behaviour of bird interests. As noted above uncertainties are high and the type and significance of effects identified from the Development are not anticipated to alter as a result.
12, 13	Hydrology and Hydrogeology and Geology and Peat	Shift to wetter winters and dryer summers	Limited change to future baseline and to the identified effects of the Development.

Given the relatively limited magnitude of change in climate parameters predicted over the operation of the Development, negligible changes to the baseline for environmental receptors are anticipated during this period. No further assessment is required within the aforementioned technical chapters.

No additional significant effects will occur as a result of climate change during the operational phase of the Development.

15.6 MITIGATION AND RESIDUAL EFFECTS

As detailed in Section 15.5.2.3, the Development will have a positive effect due to the CO_2 emission savings for the operational lifetime and beyond resulting in a net benefit of the Development to reducing climate change. Any negative effects as a result of the Development are of such limited, and negligible nature, that they are not significant in terms of the EIA Regulations. As such, no mitigation is required under the EIA Regulations other than that already embedded into the Development and recommended as best practice.

An iterative design approach was taken for the layout of the Development to avoid siting infrastructure in deep peat, where possible, to minimise disturbance of peat soils and associated carbon losses. Further micro-siting will be informed by detailed pre-construction ground investigations. An Outline PMP has been produced and is provided as Appendix A13.2. Proposed reuses of the excavated peat are in line with the Scottish

Renewables and SEPA Guidance[42] and the outline PMP demonstrates that all excavated peat can be suitably re-used on Site. Methods for handling and storing excavated peat have been described in the Outline PMP to ensure its reuse potential is maximised and any carbon losses are minimised. Monitoring of the reinstated areas will be carried out to ensure that the environmental objectives are realised.

The Outline PMP will be updated prior to construction once more detailed site investigation data and detailed engineering designs are available. The temporary peat storage locations will be identified in the updated PMP and will be guided by a geotechnical engineer. The updated PMP will also include detailed method statements and phasing of works, and will be agreed with SEPA and the planning authority prior to construction commencing.

Other mitigation measures will include the management of wind turbines to maintain operational efficiency during their lifetime. Maintenance plans for wind turbines would be developed to maximise turbine output and efficiency. Key performance indicators to monitor and track operational efficiency would be developed.

15.7 CUMULATIVE EFFECT ASSESSMENT

The Scottish and UK Governments have set ambitious targets for reducing greenhouse gas emissions by 2045 and 2050 respectively. The Development, in conjunction with other renewable energy developments, will contribute to Scotland and the UK's aims to reduce carbon emissions and achieve meet its ambitious greenhouse gas emissions targets.

DUKES 2020 details that renewable electricity represented 33% of total UK generation in 2019, which is the first time they have accounted for more than one third of the total generation. This is driven by increased capacity specifically in offshore and onshore wind. Onshore wind was the leading renewable technology in terms of capacity, at 29.9 %.

The Development will contribute up to 49.9 MW of installed capacity which will contribute to increasing renewable energy generation capacity within Scotland and the UK.

The cumulative effect of the Development with other UK renewable energy generation is considered to be a fundamental change in the climate effects of UK energy supply and contribute to the UK's legally binding emission reduction targets. This represents a **major, positive significant effect** in terms the EIA Regulations.

15.8 SUMMARY OF EFFECTS

Table 15.10 provides a summary of the effects detailed within this Chapter.

Table 15.10 Summary of Effects

Receptor	Potential Effect	Significance of Effect	Mitigation Proposed	Residual Effect
Vulnerability of Development to Climate Change				
Development Infrastructure and generation capacity.	Changes to generation capacity through changes in wind speed.	Negligible	None Mitigation is embedded in design.	None

[42] Scottish Renewables, SEPA (2012) Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and Minimisation of Waste [Online] Available at: https://www.gov.scot/Topics/Business-Industry/Energy/Energy-sources/19185/17852-1/CSavings/guidancepeatwaste (Accessed 14/08/20)

Receptor	Potential Effect	Significance of Effect	Mitigation Proposed	Residual Effect
Vulnerability of Development to Climate Change				
Development Infrastructure and operational efficiency.	Damage to infrastructure or operation due to changes in temperature.	Negligible	None	None
Influence of the Development on Climate Change				
Climate - average temperature predictions as linked to GHG emissions.	Reduction in GHG emissions through offsetting of existing conventional generation.	Positive significant effect Major cumulative positive effect.	None Embedded mitigation has reduced payback period and maximise positive impact.	Significant contribution cumulatively to regional emissions and renewable energy generation targets.
Effects on Environmental Receptors				
Environmental Receptors assessed in individual chapters of EIA Report	Change to future baseline of receptors and assessment results.	Negligible Little change over time period to baseline condition of receptors.	None Mitigation as identified in individual assessment chapters.	None

15.9 STATEMENT OF SIGNIFICANCE

The predicted future climatic baseline conditions are highly unlikely to affect the operation of the Development. The Development will have a positive effect on carbon savings and a significant positive effect when considered cumulatively with Scottish renewable energy deployment. This is a positive significant effect in terms of the EIA Regulations.

No additional significant effects to those already identified within the EIA Report will occur as a result of climate change during the operational phase of the Development.